APPENDIX **G**

Comparison Between 1993 and 2002 Safety Compatibility Zone Examples

OVERVIEW

The 1993 edition of this *Handbook* featured a diagram (Figure 9G) depicting examples of safety zone configurations for general aviation runways. The examples of safety compatibility zones depicted in Figure 9K of the current volume represent a refinement of that earlier work. Because of this relationship, the description of the analyses supporting the original delineation of safety zones is not repeated in the body of the present *Handbook* edition. For continuity, however, the 1993 analyses are summarized in the first part of this appendix.

Runway length was the only identified variable among the three general aviation runway safety zone configuration examples illustrated in the 1993 *Handbook*. Figure 9K of the current edition both notes the additional assumptions associated with the original three examples and adds three new examples in which other variables are taken into account. Figure 9L illustrates basic safety zones for runways at large air carrier airports and military airports. In the three examples brought forward from the 1993 *Handbook*, slight modifications have been made to the original configurations. These differences are summarized in the second section of this appendix.

PREVIOUS SAFETY COMPATIBILITY ZONES ANALYSIS

The safety compatibility zone examples presented in Figure 9G of the 1993 *Handbook* were created through analysis of the general aviation aircraft accident location data gathered for that purpose. The following steps were involved:

- Several basic geometric shapes potentially applicable to use as safety zones were identified;
- The efficiency of the various shapes in capturing the greatest number of accident location data points in the smallest area was assessed;
- Particular sizes at which one shape zone becomes more efficient than another were identified; and
- Shapes and dimensions for an overall set of safety zones were established.

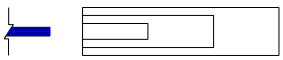
Basic Safety Zone Shapes and Sizes

To develop geometrically shaped safety compatibility zones which better reflect the geographic pattern of aircraft accidents, both the shapes and sizes of the zones must be decided. The approach used in making this decision was to compare, over a range of sizes, the relative efficiency of various safety zone shapes in capturing the most accident sites within the same amount of area. This mea sure is referred to here as the capture rate.

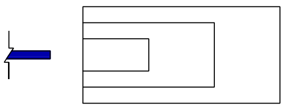
For the purposes of this analysis, six different safety zone shapes were examined as depicted on the next page. Three of the shapes are rectangles with varying aspect (length to width) ratios; one is a trapezoid; and two are fan-shaped sectors of a circle centered on the runway end.

The comparative capture rates of these alternative shapes is graphed in Exhibits G–1 through G–4. This analysis used the accident-site data obtained from the 1993 *Handbook* database. The 1993 database contained information of 400 accidents.

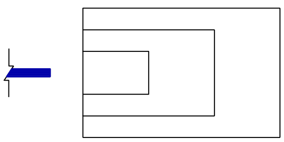
Basic Safety Zone Shapes



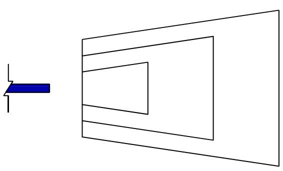
4:1 Rectangles



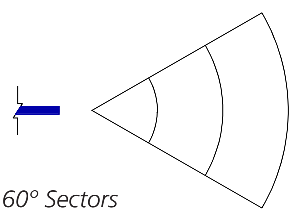
2:1 Rectangles



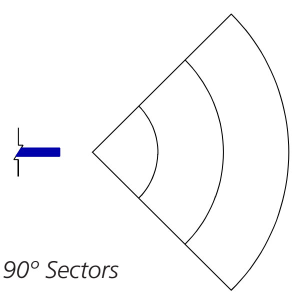
3:2 Rectangles



2:1:1.6 Trapezoids



60° Sectors



90° Sectors

Data on arrival accidents is graphed in the first two figures; departure accident data in the second pair. The departure accident site data is graphed based upon distances normalized for the length of the runway — that is, acreage and distance are plotted with respect to the departure (climb-out) end of the runway. Within each pair of figures, the first examines a large area encompassing 1,200 acres and extending 2 to 3 miles from the runway ends. The second graph in each set focuses on the 100 acres closest to the runway ends.

Several observations can be made from a review of the graphs:

- The optimum safety zone shape for capturing arrival accident sites is not necessarily the best shape for en compassing departure accident sites, and vice versa.
- The most efficient shapes for the area closest to a runway end generally do not have the greatest capture rates over a more extended area.
- For close-in arrival accident sites, the two fan-shaped sectors capture the most points per acre. These shapes also do well for close-in departure accidents sites, although other shapes are generally equivalent.
- Over larger acreages, the sector shapes and the narrow rectangle have slightly better capture rates for arrival accident sites, but the wide rectangles and the trapezoid shape do better for departures.

Overall Set of Safety Zones

A basic objective to be kept in mind when defining safety zones is that the degree of risk represented by each zone should be relatively equal throughout that zone. From the above conclusions, as well as simple examination of the accident location pattern diagrams, it is evident that no single safety zone can meet this objective if a substantial portion of the accident sites are to be encompassed. A set of zones having different shapes and sizes is needed.

Deciding where to draw the zone boundaries would be easy if the accident distribution pattern changed in distinct increments relative to the airport runway. As with noise levels, though, accident site concentrations diminish in a more-or-less-continuous gradient with increased distance from the runway.

Given this reality, the capture rate graphs were reviewed to look for places where relatively sharp changes in the distribution patterns are apparent. Where a curve is steep, relatively small increments of acreage significantly increase the percentage of accident sites encompassed. On the other hand, the flatter sections indicate that large amounts of acreage would have to be added to the size of a safety zone in order to gain a few more percentage points on the vertical scale. The most distinguishable breaks in the slope of the curve occur at three points:

- Within the first 20 to 25 acres, all of the curves are steep. This area (about 650-by-1,300 to 750-by-1,500 feet at an aspect ratio of 2:1) is roughly that of a runway protection zone for a visual or non-precision instrument runway with approach visibility minimums of 1 mile or more.
- At about 100 acres the curves begin to flatten.
- In the 100-to-300-acre range, the slopes of the curves become even more shallow.
- Finally, at about 500 to 600 acres, the curves become quite flat. Even in this large acreage range, it should be noted that only some 60% of the arrival accident sites and 50% of the departure accidents

sites occurring within 5 miles of the runway are encompassed. This is reflected in the accident location pattern diagrams (see Appendix F) which show numerous accident sites throughout the runway environs. Also, accident sites adjacent to the runway and in areas lateral to the runway end are not contained within any of the safety zone shapes evaluated here.

Next, a complete set of safety zones and possible dimensions for each zone were postulated. A decision was made to hold the number of zones to no more than six. The accident location diagrams, the capture rate curves described above, and typical zones adopted by various ALUCs were used as guidance. The percentage of accident sites in each zone was then counted from the database and the capture rate was computed. Finally, the dimensions were adjusted in an effort to obtain a reasonable balance between the percentage of points falling within each zone and the zone's capture rate. One exception was the runway protection zone (RPZ) size which was fixed at standard FAA dimensions. These calculations were done for three different subsets of the database: accidents associated with runways less than 4,000 feet long; those for runways 4,000 to 5,999 feet in length; and ones involving runways of 6,000 feet length or greater. For the purposes of the RPZ sizes, runways in the short-length group were assumed to have a visual approach; those in the mid-length group to have a nonprecision approach; and runways in the longest range to have a precision approach.

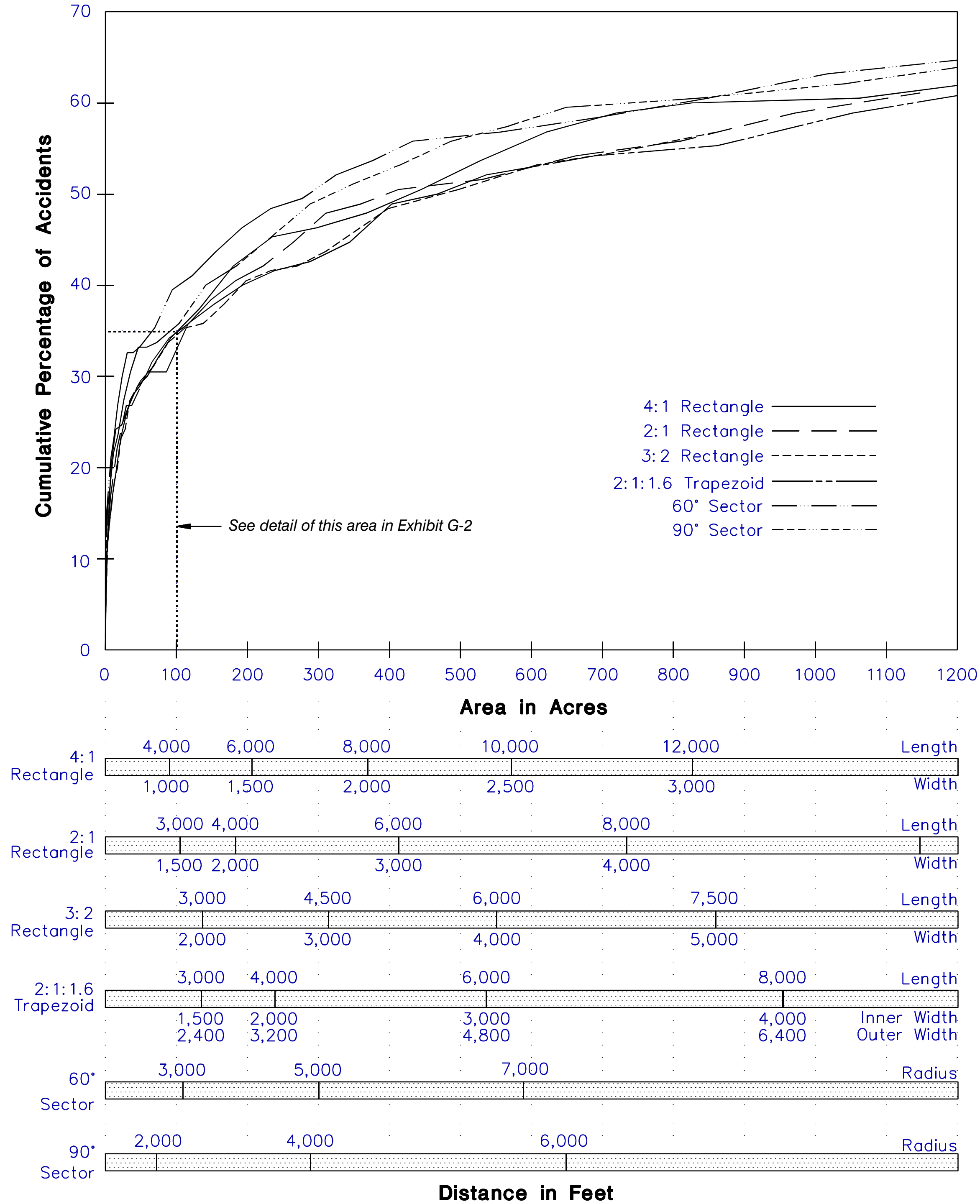
DIFFERENCES BETWEEN OLD AND NEW SAFETY ZONE EXAMPLES

An important caveat included with the previous analysis was that the safety zone shapes and sizes as shown were presented only to illustrate the way in which the accident data could be used to create a set of safety compatibility zones. The results were derived in a purely mathematical manner. The only variables considered were runway length and, with respect to RPZs, the type of approach. The expectation was that the results would serve only as a starting point for ALUCs to use in delineating safety compatibility zones for a particular runway. The examples indicated in Figure 9G of the 1993 *Handbook* explicitly were not intended to represent Division of Aeronautics recommendations. However, passage of the 1994 legislation requiring ALUCs to be "guided by" the *Handbook* when preparing compatibility plans gave new meaning to the previous Figure 9G. The depicted example sometimes became a convenient end product with little consideration given to conditions present at a specific airport or to the relationship between the geometry of safety zones and the land use criteria applicable within them.

Given this status, the safety zone configuration examples from the 1993 *Handbook* were reexamined as part of the analysis for this present edition. The major objectives of this effort were to expand upon the range of examples provided and to more clearly indicate the assumptions associated with each example. Additionally, various factors are identified which can and typically should be used to adjust the basic zones and/or criteria. The purpose of these changes is to emphasize that, rather than simply selecting a predefined set of compatibility zones from the *Handbook*, airport land use commissions are expected to evaluate the specific conditions at the airport involved and make adjustments to the zones as necessary.

With respect to the three examples brought forward from the 1993 edition, a reassessment of the previously identified safety zones relative to the expanded accident database reveals no vastly different results or need for major changes in the shapes or sizes of the zones as postulated. Several small modifications are indicated in Figure 9N, however. Some zones have been made slightly larger or smaller. The most notable change is that the outer ends of the sideline zones (Zone 5) have been shifted into either the inner safety zone (Zone 2) or the inner turning zone (Zone 3). These areas adjacent to the runway ends have concentrations of accidents which are more equivalent to the latter zones than to the areas adjacent to the middle of runways where accidents are relatively few. The inner safety zones have also been shifted closer to the runway.

The color diagrams at the end of this appendix provide a comparison between the previous and new general aviation runway safety compatibility zones examples. To aid visualization of the relationship of the zones to aircraft accident locations, the data points from the expanded (873-point) general aviation aircraft accident database and the associated accident distribution contours for each runway length range are illustrated as well.

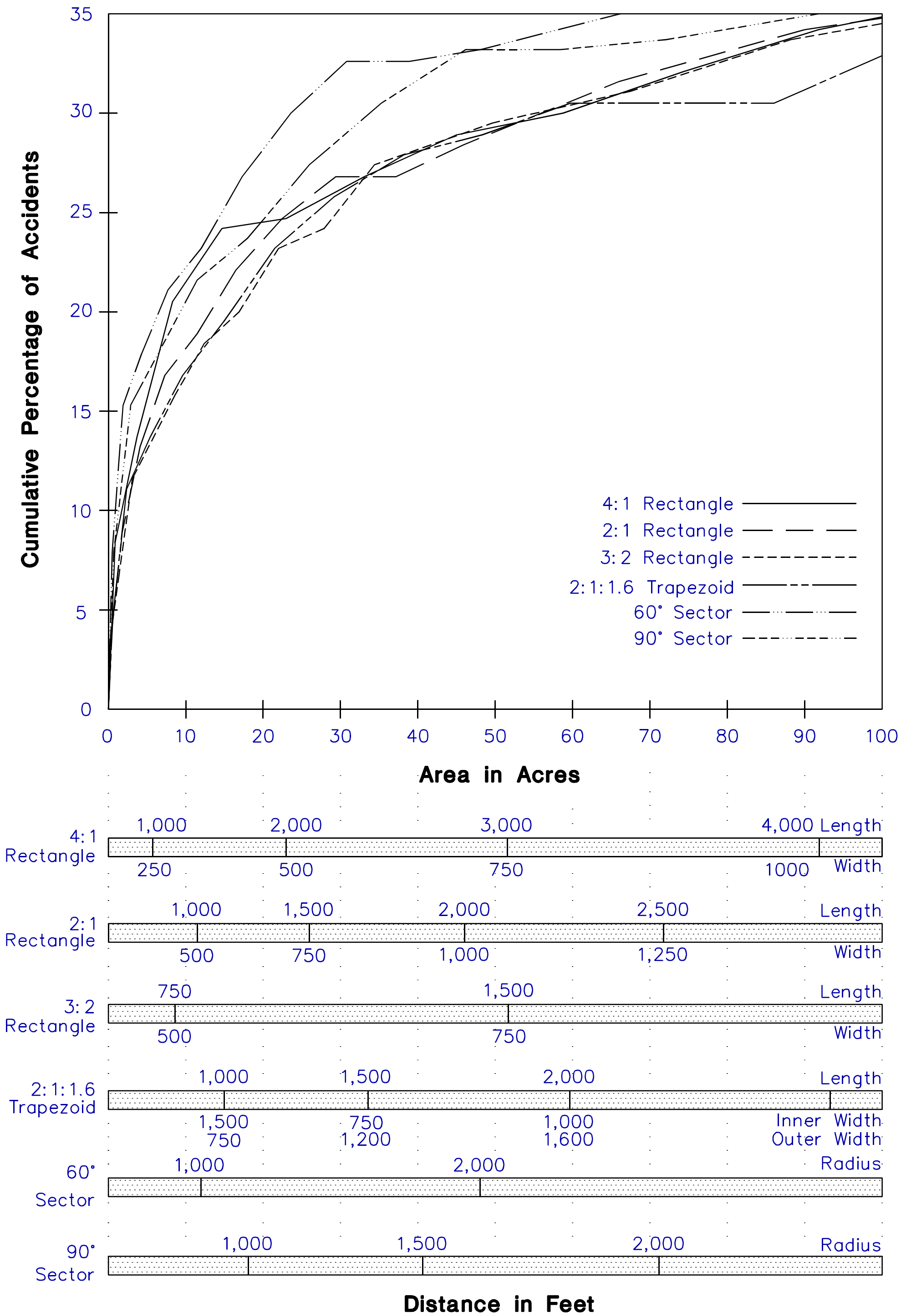


Source: Caltrans Airport Land Use Planning Handbook (1993)

FIGURE G-1

Comparison of Safety Zone Capture Rates

Arrival Accident Sites

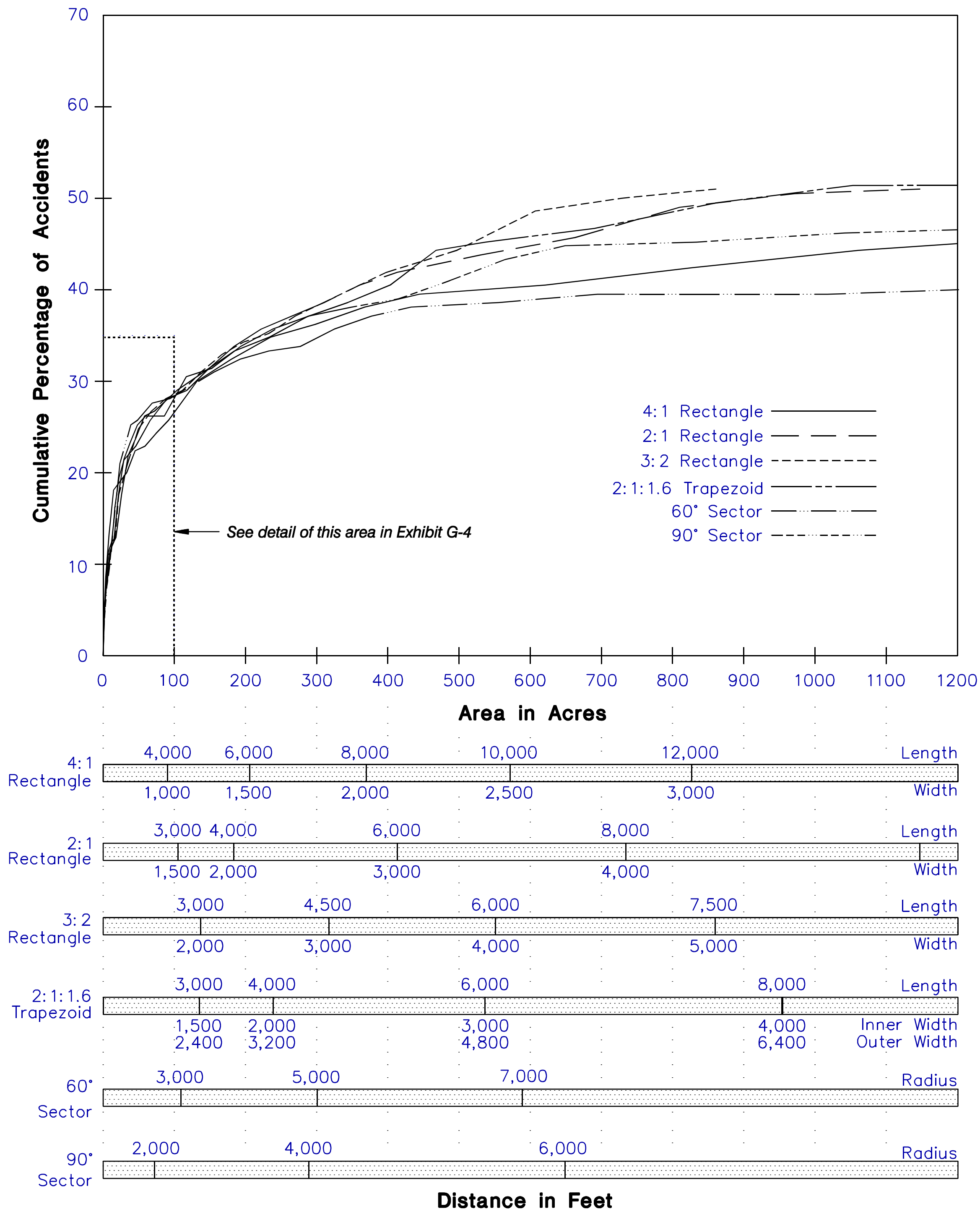


Source: Caltrans Airport Land Use Planning Handbook (1993)

FIGURE G-2

Comparison of Safety Zone Capture Rates

Close-In Arrival Accident Sites

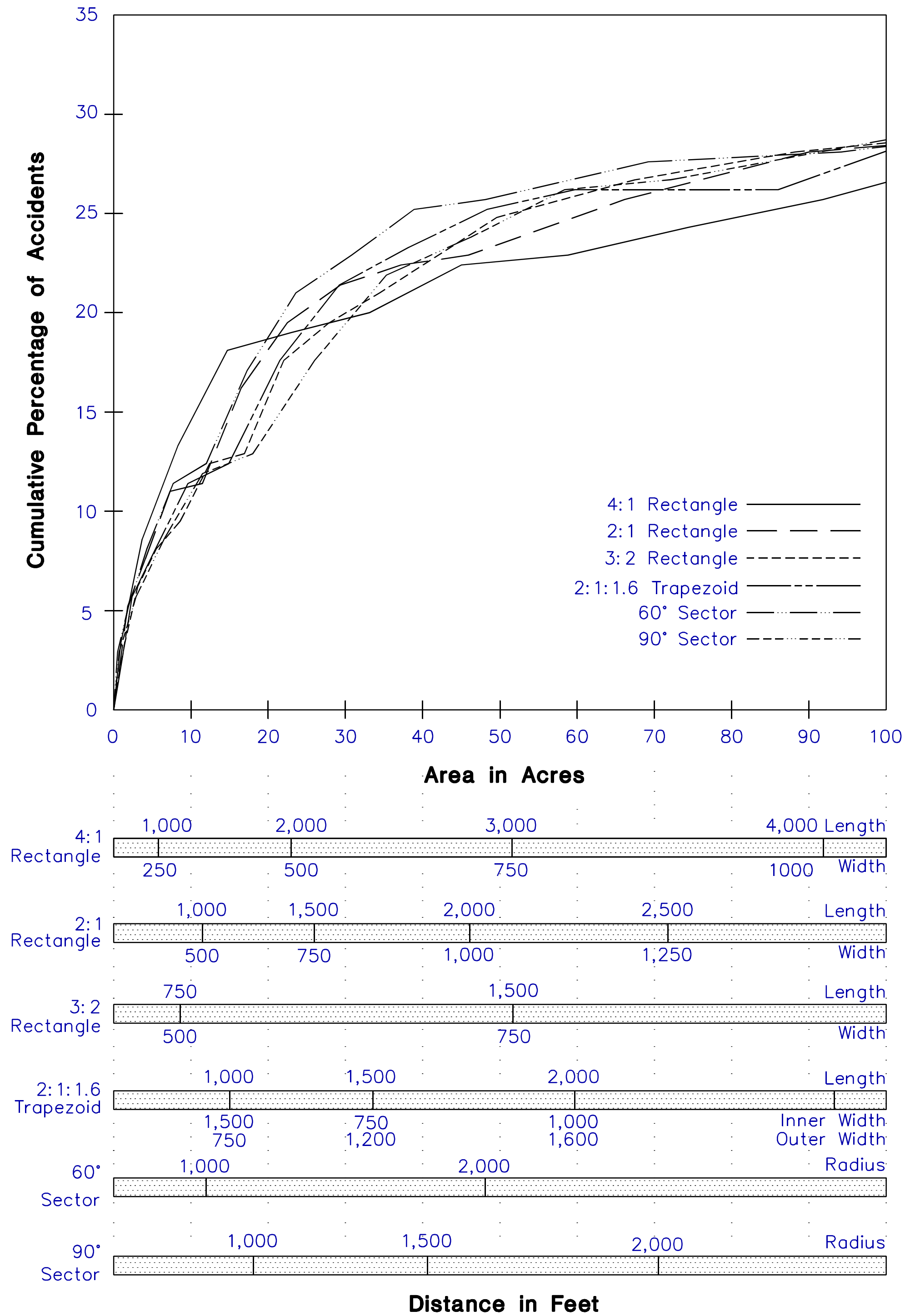


Source: Caltrans Airport Land Use Planning Handbook (1993)

FIGURE G-3

Comparison of Safety Zone Capture Rates

Departure Accident Sites



Source: Caltrans Airport Land Use Planning Handbook (1993)

FIGURE G-4

Comparison of Safety Zone Capture Rates

Close-In Departure Accident Sites

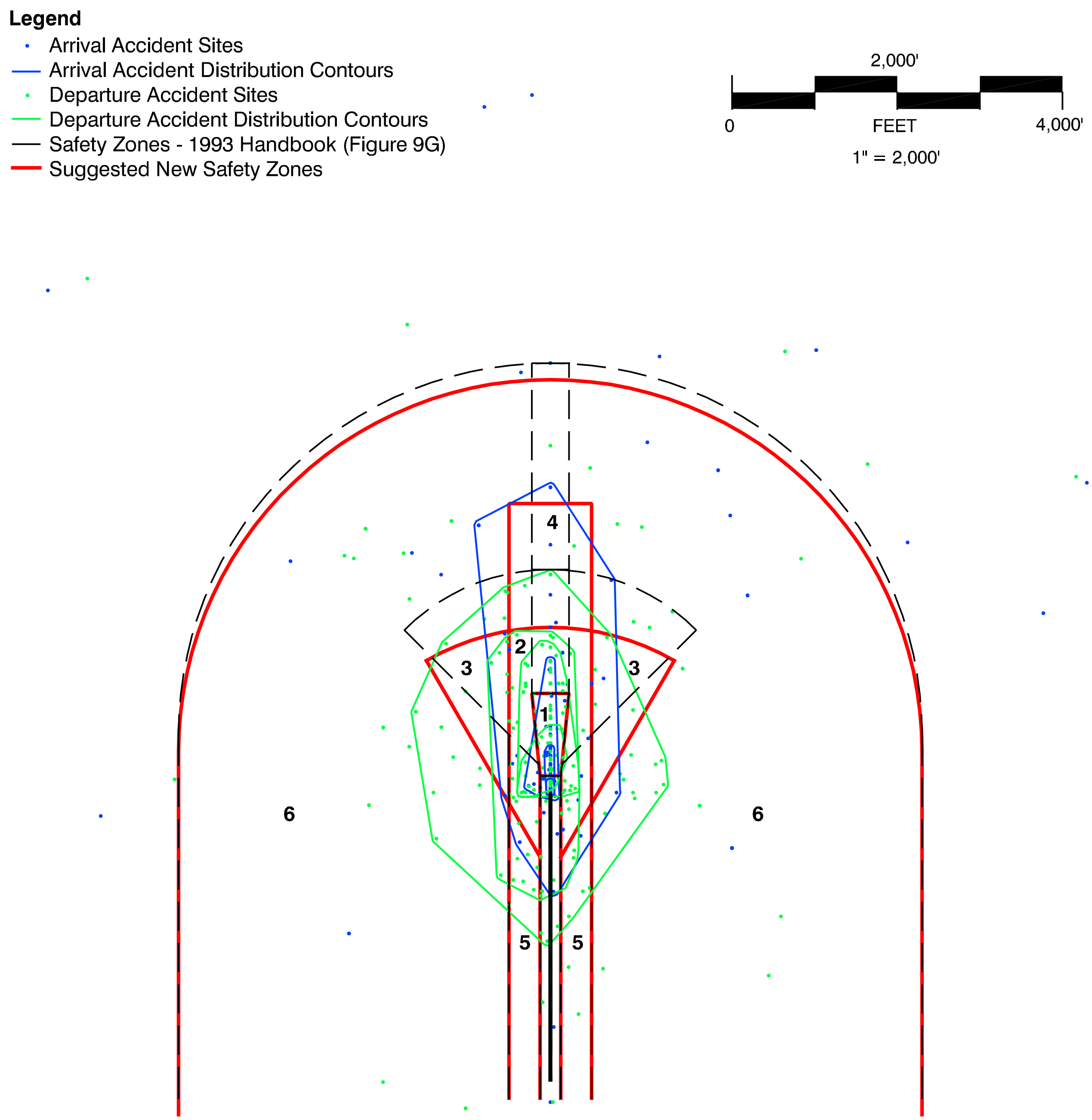


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EXHIBIT G-5

Safety Compatibility Zones Comparison

Accidents on Runways of Less than 4,000 Feet

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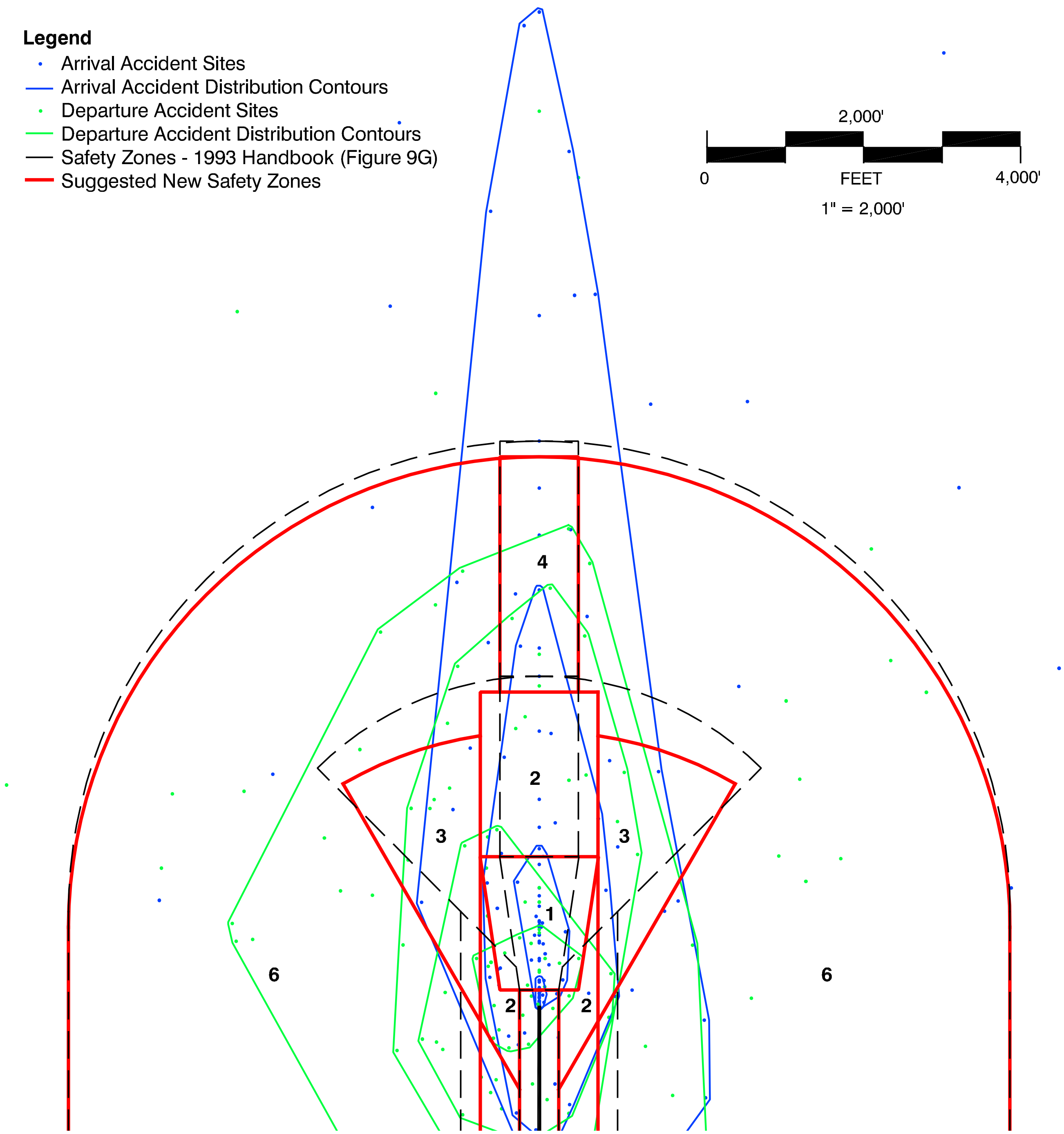

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EXHIBIT G-6

Safety Compatibility Zones Comparison

Accidents on Runways of 4,000 to 5,999 Feet

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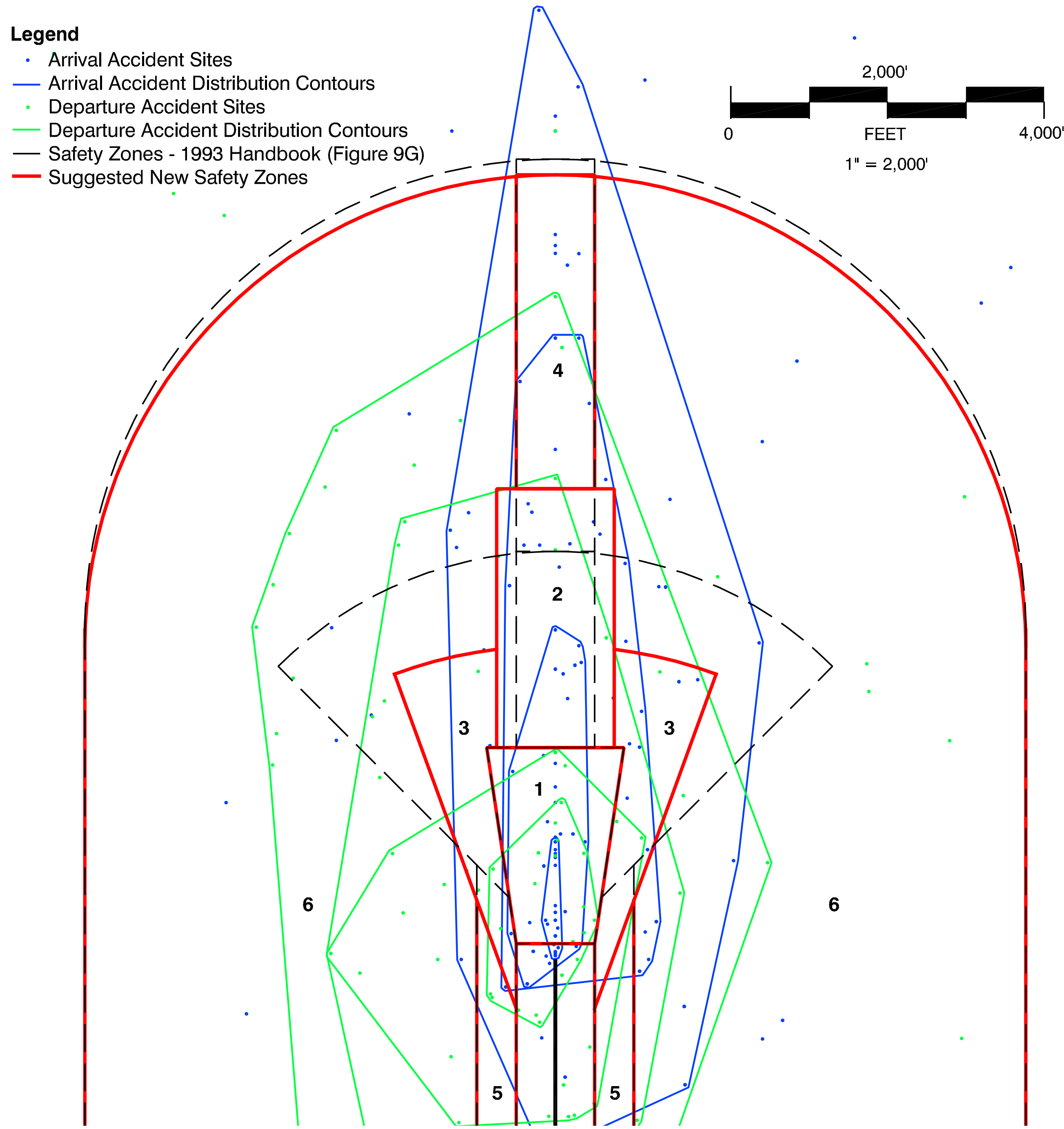

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EXHIBIT G-7

Safety Compatibility Zones Comparison

Accidents on Runways of 6,000 Feet or More